# PONDICHERRY UNIVERSITY-ET 336 R

## B.Tech. DEGREE EXAMINATION, APRIL 2014.

## Third Semester-Electronics and Communication Engineering

## ENGINEERING ELECTROMAGNETICS

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Time: Three hours Maximum : 75 marks

**PART A — (10 × 2 = 20 marks)**

**Answer ALL questions. All questions carry equal marks.**

1. Define Divergence theorem.
   **Ans 1.** For answer refer: **Page 30, topic 1.6.3.**
2. Define Stoke's theorem.
   **Ans 2.** For answer refer: **Page 28, topic 1.6.1.**
3. What is Continuity equation?
   **Ans 3.** For answer refer: **Page 87, topic 2.12.2.**
4. What is conduction current and displacement current?
   **Ans 4.** For answer refer: **Page 68, topic 2.6.2 & 2.6.3.**
5. Define Biot-Savart's law.
   **Ans 5.** For answer refer: **Page107, topic 3.4.**
6. Define Ampere's law.
   **Ans 6.** For answer refer: **Page 112, topic 3.6.**
7. Write the Expression for inductance of a Toroid.
   **Ans 7.** For answer refer: **Page 134, topic 3.13.2**, $L = \frac{\mu N^2 A}{2\pi R}$.
8. Define Energy Density.
   **Ans 8.** For answer refer: **Page 139, topic 3.14.1**. Energy stored per unit volume is known as energy density. For long solenoid, $\frac{\text{Energy}}{\text{unit volume}} = \frac{1}{2}\mu H^2$.
9. State Modified Ampere's Circuital law.
   **Ans 9.** For answer refer: **Page 112, topic 3.6.**
10. State Maxwell's Equations in point and integral forms.
    **Ans 10.** For answer refer: **Page 155, topic 4.3.**

**PART B – (5 × 11 = 55 marks)**

**Answer ALL questions, One from each Unit. All questions carry equal marks.**

**UNIT I**

11. (a) Define Potential Gradient.
**Ans 11. (a)** For answer refer: **Page 59, topic 2.2.2.**

11. (b) Explain in detail about cylindrical co-ordinate system with neat diagram. (9)
**Ans 11. (b)** For answer refer: **Page 11, topic 1.3.2.**

Or

12. Derive the expression for electric field due to surface charge and line Charge. (11)
**Ans 12.** For answer refer: **Page 33, topic 1.8.3 and topic 1.8.1**; surface charge = circular sheet charge.

**UNIT II**

13. Derive the expression for electric field due to Infinite Uniformly Charged sheet. (11)
**Ans 13.** For answer refer: **Page 37, topic 1.9** "State Gauss's law"; Page 40, topic 1.9.4 "Infinite surface charge".

Or

14. (a) A straight line charge of length 12 cm carries a uniformly distributed charge of $0.3 \times 10^{-6}$ C/cm length. Determine the magnitude and direction of the electric fields intensity at a point located at a perpendicular distance of 3 cm above the wire and at a horizontal distance of 3 cm from one end of the line charge. Medium is air. (6)

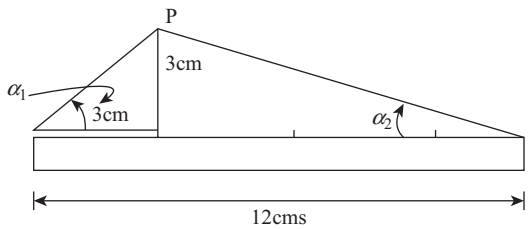
**Ans 14. (a)** length $\ell = 12 \text{ cm} = 12 \times 10^{-2}$ m

Line charge density $\rho = 0.3 \times 10^{-6}$ C/cm $= \dfrac{0.3 \times 10^{-6} \text{C}}{1 \times 10^{-2} \text{m}}$

$$\rho = 0.3 \times 10^{-4} \text{ C/m}$$

Permittivity = $\varepsilon_0$

$$h = 3 \text{ cms} = 3 \times 10^{-2} \text{ m}$$




$$E_x = \left( \frac{\lambda}{4\pi\varepsilon_0 h} \right) \left( \sin\alpha_2 - \sin\alpha_1 \right)$$

$$E_y = \left(\frac{\lambda}{4\pi\varepsilon_0 h}\right)\left(\cos\alpha_1 + \cos\alpha_2\right)$$

$$\alpha_1 = \tan^{-1}\left(\frac{3}{3}\right) = \tan^{-1}(1) = 45°$$

$$\alpha_2 = \tan^{-1}\left(\frac{3}{9}\right) = 18.43°$$

$$E_x = \frac{0.3\times10^{-4}}{4\pi\varepsilon_0 \times 3\times10^{-2}}\left[\sin 18.43° - \sin 45°\right]$$

$$E_x = \frac{0.3\times10^{-4}}{4\pi\varepsilon_0 \times 3\times10^{-2}}(-0.391) = 3.51\times10^{6}\ \text{V/m}$$

$$E_y = \left(\frac{\lambda}{4\pi\varepsilon_0 h}\right)\left(\cos 18.43 + \cos 45\right) = \left(\frac{0.3\times10^{-4}}{4\pi\varepsilon_0 \times 3\times10^{-2}}\right)(1.66) = 14.88\times10^{6}\ \text{V/m}.$$

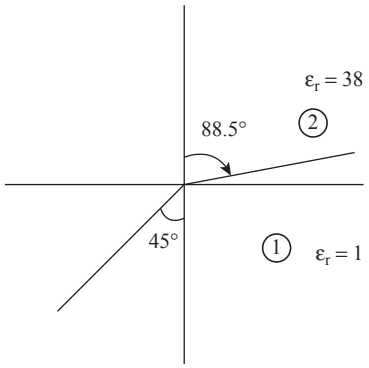
14. (b) Explain the boundary conditions at olielectric surfaces.
**Ans 14. (b)** Olielectric means Insulator.

Ceramic is one of the best insulator and its relative permittivity is "38"
Let's consider the interface between air and ceramic insulator.

$$\varepsilon_r = 38$$

For a charge free surface,

$$\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$$




$$\frac{1}{\tan\theta_2} = \frac{1}{38}$$

$$\Rightarrow \quad \tan\theta_2 = 38$$

$$\theta = \tan^{-1}(38) = 88.5°$$

## UNIT III

15 (a) Derive the expression for Magnetic field Intensity at any point on the axis of circular current carrying coil.

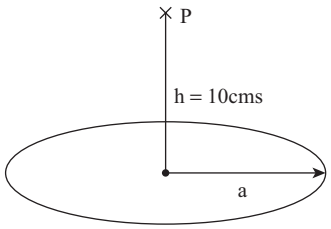
**Ans 15. (a)** For answer refer: **Page 119, topic 3.7.2.**

15 (b) Calculate the Magnetic flux density due to circular coil of 100 AT and area of 70 $cm^2$ on the axis of the coil at a distance of 10 cm from the center.

**Ans 15. (b)** $I = 100AT$

$$\text{Area} = 70\ \text{cm}^2 = 70 \times (10^{-2}\ \text{m})^2$$

$$A = 70 \times 10^{-4}\ \text{m}^2$$




$$\pi a^2 = 70 \times 10^{-4}\ \text{m}^2$$

$$a = 47.2 \times 10^{-3}\ \text{m}$$

$$h = 10 \times 10^{-2}\ \text{m}$$

$$H = \left[\frac{I\,a^2}{2(a^2+h^2)^{\frac{3}{2}}}\right]\hat{k} = \frac{100 \times (47.2 \times 10^{-3})^2}{2\left[\left(47.2 \times 10^{-3}\right)^2 + \left(10 \times 10^{-2}\right)^2\right]^{\frac{3}{2}}}$$

$$H = \frac{222.78 \times 10^{-3}}{2.704 \times 10^{-3}} = 82.4$$

$$H = 82.4\ \text{AT/m.}$$

Or

16. (a) Define
(i) Magnetic Field Intensity. (2)
(ii) Magnetic Dipole (2)
(iii) Magnetic flux density. (2)

**Ans 16. (a) (i)** The strength of the magnetic field at a point is defined as the magnetic field intensity at that point.

**Ans 16. (a) (ii)** For answer refer: **Page 128, topic 3.10.1.**

**Ans 16. (a) (iii)** For answer refer: **Page 105, topic 3.2.**

16. (b) Explain the boundary conditions at the Magnetic surfaces.

**Ans 16. (b)** For answer refer: **Page 132, topic 3.12.**

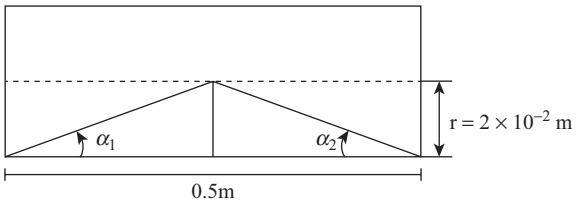
## UNIT IV

17. (a) State and Explain Faraday's law of Electromagnetic Induction.
**Ans 17. (a)** For answer refer: **Page 154, topic 4.2**. Faraday's law, Lenz's law and topic 4.2.1.

Explanation of Lenz's law point (b), fig 4.9.

17. (b) Evaluate the inductance of a solenoid of 2500 turns wound uniformly over a length of 0.5 m on a cylindrical paper tube, 4cm in diameter. The medium is air. (5)
**Ans 17. (b)** No. of turns = 2500

Length = 0.5 m
Diameter = 4 cm = $4 \times 10^{-2}$ m
Radius = $2 \times 10^{-2}$ m
Permeability = $\mu_o$




$$L = \frac{\mu_o N^2 A}{2\ell}\left(\cos\alpha_1 + \cos\alpha_2\right)$$

$$\tan\alpha_1 = \frac{r}{\left(\frac{d}{2}\right)} = \frac{2\times10^{-2}}{0.25} = \frac{2\times \cancel{10^{-2}}}{25\times \cancel{10^{-2}}}$$

$$\tan\alpha_1 = 0.08$$

$$\alpha_1 = 4.58°$$

$$A = \pi r^2 = \pi(2\times10^{-2})^2 = 1.25\times10^{-3}$$

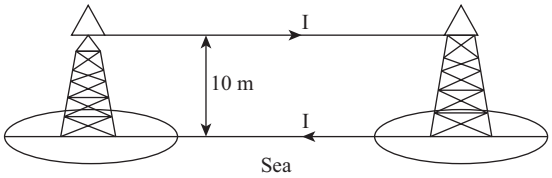
$$L = \frac{4\pi\times10^{-7}\times(2500)^2\times1.25\times10^{-3}}{2(0.5)}\left[\cos 4.58 + \cos 4.58\right]$$

$$L = 19.57\times10^{-3}\ \text{H} = 19.57\ \text{mH}.$$

Or

18. (a) Derive the Expression for the Inductance of a co-axial transmission-line. (6)
**Ans 18. (a)** For answer refer: **Page 135, topic 3.13.3**

18. (b) A wire of 1 cm diameter is suspended at a constant height of 10m above sea water which constitutes the return conductor. Calculate the inductance of the system per km. (5)
**Ans 18. (b)** For answer refer: **page 137, Topic 3.13.5**.




Inductance of two Transmission line is given by

$$L = \left(\frac{\mu_0}{4\pi}\right)\left[\mu_r + 2\ell n\left(\frac{d^2}{ab}\right)\right]$$

Considering that the notional return path is also of same diameter, we have,

$$a = b = \frac{1}{2}\text{cm} = 0.5\times10^{-2}\text{ m} = 5\times10^{-3}\text{ m}$$
$$d = 10\text{ m}$$

Total Inductance of T.L per unit length, $L = \left(\frac{\mu_0}{4\pi}\right)\left[\mu_r + 2\ell n\left(\frac{d^2}{ab}\right)\right]$

$$= \left(\frac{\mu_0}{4\pi}\right)\left[100 + 2\ell n\left\{\frac{10^2}{(5\times10^{-3})^2}\right\}\right] \text{ (Let's take } \mu_r = 100\text{)}$$

$$= 13.04\times10^{-6}\text{ H}$$
$$L = 13.04\,\mu\text{H}.$$

**UNIT V**

19. State and explain poynting's theorem.
**Ans 19.** For answer refer: **Page 204, topic 5.8.**

Or

20. (a) Define slepian vector.
**Ans 20. (a)** Slepian vector "$S_1$", is used to describe the flow of energy in EM waves. It is sum of two vectors as shown in below equation.

$$S_1 = S + \text{curl (VH)} = (E\times H) + \nabla\times(VH)$$

$S_1$ = Slepian vector E = Electric field Intensity
V = Electric potential H = Magnetic field Intensity.

20. (b) Explain about the energy in Electromagnetic field in detail.
**Ans 20. (b)** For answer refer: **page 78, Topic 2.10** fully till 79 end.

For answer refer: **page 138, Topic 3.14 and 3.14.1.**